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Method for run-length encoding of a bitmap data stream

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Method for run-length encoding of a bitmap data stream

Field of the invention

- 5 This invention relates to a method for encoding a data stream, particularly a bitmap coded subtitling data stream.

Background

- 10 Broadcast or read-only media containing video data may also comprise subpicture data streams, containing textual or graphical information needed to provide subtitles, glyphs or animation for any particular purpose, e.g. menu buttons.
- 15 Since displaying of such information may usually be enabled or disabled, it is overlaid on the associated video image as an additional layer, and is implemented as one or more rectangular areas called regions. Such region has specified a set of attributes, like e.g. area size, area position or
- 20 background color. Due to the region being overlaid on the video image, its background is often defined to be transparent so that the video image can be seen, or multiple subpicture layers can be overlaid. Further, a subtitle region may be broader than the associated image,
- 25 so that only a portion of the subtitle region is visible, and the visible portion of the region is shifted e.g. from right to left through the whole subtitle area, which looks as if the subtitles would shift through the display. This method of pixel based subtitling is described in the
- 30 European Patent application EP02025474.4 and is called cropping.

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Subtitles were originally meant as a support for
handicapped people, or to save the costs for translating a
film into rarely used languages, and therefore for pure
subtitle text it would be enough if the subtitle data
5 stream contained e.g. ASCII coded characters. But subtitles
today contain also other elements, up to high-resolution
images, glyphs or animated graphical objects. Handling of
such elements is easier if the subtitling stream is coded
in bitmap format, with the lines of an area and the pixels
10 within a line being coded and decoded successively. This
format contains much redundancy, e.g. when successive
pixels have the same color value. This redundancy can be
reduced by various coding methods, e.g. run-length encoding
(RLE). RLE is often used when sequences of data have the
15 same value, and its basic ideas are to code the sequence
length and the value separately, and to code the most
frequent code words as short as possible.
Particularly when encoding the subtitle layer for 1920x1280
pixels high-definition video (HDTV), a coding algorithm
20 that is optimized for this purpose is needed to reduce the
required amount of data.

Summary of the Invention

25

The purpose of the invention is to disclose a method for
optimized encoding of subtitle or subpicture layers for
high-resolution video, such as HDTV, being represented as
bitmap formatted areas that may be much broader than the
30 visible video frame.

This method is disclosed in claim 1. An apparatus for
encoding that utilizes the method is disclosed in claim 7.

An apparatus for decoding that utilizes the method is disclosed in claim 8.

According to the invention, four-stage run-length encoding
5 (RLE) is used for this purpose, with the shortest code words being used for single pixels having individual color values other than transparent, the second shortest code words being used for shorter sequences of transparent
10 pixels, the third shortest code words being used for longer sequences of transparent pixels and shorter sequences of pixels of equal color other than transparent, and the fourth shortest code words being used for longer sequences of pixels of equal color other than transparent. Usually,
15 most of the pixels within the subtitle layer are transparent. Other than for conventional RLE, where the most frequent data use the shortest code words, this method comprises using the second shortest code words for short sequences of the most frequent color, and the third
20 shortest code words for longer sequences of the most frequent color and also short sequences of other colors. Shortest code words are reserved for single pixels of other than the most frequent color. This is advantageous when pixels of the most frequent color almost always appear in sequences, as being the case for transparent pixels in the
25 subtitle layer, while single pixels of individual color are more likely to be not transparent.

Advantageously, a code according to the inventive method incorporates only few redundant code words, which are
30 defined to be among the longer code words. E.g. a single pixel of any color other than transparent is ideally coded with a code word of the shortest type, but a code word of the third shortest type may be used as well, with the

sequence length being one. Though the latter possibility will usually not be used for this purpose, these unused code words, or gaps in the code word space, can be used for transportation of other information. An example is the end-
5 of-line information that can be used for resynchronization. According to the invention, the shortest redundant code word is used to code this information.

As another advantage, the disclosed method reduces the
10 amount of required data, thus compressing the subtitle data stream, with the compression factor depending on the contents of the data stream. Particular high compression factors are achieved for data combinations that appear very often in typical subtitling streams. These are sequences of
15 length shorter than e.g. 64 pixels that have the same color value, but also sequences of transparent pixels having any length and single pixels having individual color values. The first of these groups are often used in characters or glyphs, the second of these groups is used before, between
20 and after the displayed elements of the subtitling stream, and the third of these groups is used in images, or areas with slightly changing color. Since transparent pixels hardly ever appear in very short sequences, e.g. less than
25 three pixels, it is sufficient to code them not with the shortest but only with the second shortest code words.

Simultaneously, the inventive method may handle efficiently sequences that are longer than 1920 pixels, and e.g. may be
30 up to 16383 pixels long, thus enabling very wide subtitling areas.

Further, the coding method generates a unique value representing the end of a line, and therefore in the case

of loss of synchronization it is possible to resynchronize each line.

Advantageously, the inventive method is optimized for
5 coding this combination of a number of features being typical for subtitling streams.

Therefore the amount of data required for the subtitling stream may be reduced, which leads to better utilization of
10 transmission bandwidth in the case of broadcast, or to a reduced pick-up jump frequency in the case of storage media where a single pick-up reads multiple data streams, like e.g. in Blu-ray disc (BD) technology. Further, the better the subtitling bitmap is compressed, the higher capacity in
15 terms of bit-rate will be left for audio and video streams, increasing picture or audio quality.

Advantageous embodiments of the invention are disclosed in the dependent claims, the following description and the
20 figures.

Brief description of the drawings

25 Exemplary embodiments of the invention are described with reference to the accompanying drawings, which show in

Fig.1 cropping of a subtitle area in a video frame,

Fig.2 a pixel sequence in a subtitle area,

30 Fig.3 a coding table for subtitling, including text and graphics; and

Fig.4 a table with an exemplary syntax of an extended object data segment for the Blu-ray Prerecorded standard.

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Detailed description of the invention

5 While subtitling in pre-produced audio-visual (AV) material for broadcast or movie discs is primarily optimized for representing simple static textual information, e.g. Closed Caption, Teletext or DVB-Subtitle, progress in multimedia development for presentation and animation of textual and
10 graphic information adequate to new HDTV formats requires an advanced adaptation for bitmap encoding. Fig.1 shows a video frame TV and a subtitle area SUB containing text and graphical elements G, with the subtitle area SUB being bitmap coded. The size of the subtitle area SUB may exceed
15 the video frame dimensions, as e.g. for the Blu-ray Disc Prerecorded (BDP) format subtitle bitmaps are allowed for one dimension to be larger than the video frame. Then the lines are cropped before being displayed, i.e. a portion matching the respective frame dimension is cut out of the
20 virtual line and displayed, overlaying the video image. In Fig.1, the subtitle area SUB of width B_{SUB} is cropped, so that only a portion of width B_{TV} is visible. For standard HDTV, as used e.g. for BDP, B_{TV} is 1920 pixels, while B_{SUB} may be much more.

25

Due to the rectangular shape of the subtitle area SUB, most pixels in that area are transparent. This is in an enlarged scale shown in Fig.2, in a simplified manner since usually a line SL1, SL2 on a HDTV screen TV must be several pixels
30 wide in order to be clearly visible. A line is herein understood as a horizontal structure. Each line of subtitle data usually contains one or more pixel sequences of equal color. Fig.2 shows a part of a subtitle line SL1 containing

transparent sequences PS1, PS5, but also single visible pixels PS4, shorter visible lines PS2 and longer visible lines PS3. Most pixels within a line are transparent. This is the case between characters, but also at the beginning and at the end of subtitling lines. Anyway, since lines begin and end with transparent sections, each line contains one more transparent than colored section. But transparent sections PS1, PS5 are usually longer, while for pixel sequences other than transparent, used e.g. for characters, the most frequent case is a sequence length of 64 or less. This can be recognized from a rough estimation, assuming that at least 25 characters are displayed simultaneously, and that the space between characters has about one quarter the width of a character, so that a single character may use not more than $1920/25 * (8/10) = 62$ pixels within a line. Often, a line SL2 contains only very few visible pixels, and therefore only few transparent sequences that are very long.

A code being a preferred embodiment of the invention is listed in Fig.3. It is a run-length code, comprising code words of lengths ranging from 1 byte up to 4 bytes, with 8 bits per byte. It is capable of coding 256 different colors, with one preferred color. The preferred color is in this example 'transparent', but may be any other color if adequate. A color look-up table (CLUT) may transform the decoded color values into the actual display color. Further, pixel sequences of equal color may be coded in two ranges, with the shorter range being up to 63 pixels and the longer range being up to 16383 pixels.

The shortest code words of 1 byte length are used to code a single pixel having any individual color other than the

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preferred color, which is here transparent. The color value
CCCCCCCC may range from 1 up to 255, and may represent a
color directly or indirectly. E.g. it may represent an
entry in a color look-up table (CLUT) that contains the
5 actual color code. One of the 8-bit values, containing only
zeros (00000000), serves as an escape sequence, indicating
that the following bits have to be considered as part of
the same code word. In that case, the code word tree has
four possible branches, marked by the two following bits.

10

In the first branch, indicated by the following bits being
00, valid code words have two bytes, and a shorter sequence
of up to 63 pixels is coded having the preferred color,
e.g. transparent. The only invalid code word in this branch
15 is the one that comprises only 0's, since 0 represents no
valid sequence length. This code word '00000000 00000000'
may be used for other purposes. According to the invention,
it is used to indicate the end of a line since it is the
shortest redundant code word.

20 In the second branch, indicated by the following bits being
01_b, the code word comprises another byte, and the fourteen
L bits are used to code the length of a pixel sequence of
the preferred color, e.g. transparent. Thus, the sequence
length may be up to $2^{14}-1 = 16383$. The code words where the
25 L bits have a value below 64 are redundant, and may be used
for other purposes.

In the third branch, indicated by the following bits being
10_b, the code words comprise an additional byte, and the
six L bits of the second byte represent the length of a
30 shorter sequence of up to 63 pixels, which have another
than the preferred color. The actual color is directly or
indirectly represented by the CCCCCCCC value of the third
byte. The code words with a sequence length LLLLLL below

three are redundant, since a sequence of one or two pixels of this color can be cheaper coded using one byte per pixel, as described above, and a sequence length of zero is invalid. These code words may be used for other purposes.

5 In the fourth branch, indicated by the following bits being 11₂, the code words comprise two additional bytes, wherein the remaining six bits of the second byte and the third byte give the length of a longer sequence of 64 up to 16383 pixels, and the color value CCCCCCCC of the fourth byte gives the color, directly or indirectly and not being the preferred color. The code words with a sequence length below 64 are redundant, since these sequences may be coded cheaper using the third branch. These code words may be used for other purposes.

10 The redundant code words mentioned above may be used to extend the code, e.g. add internal check sums or other information.

The extended run-length encoding table shown in Fig.3 and described above provides mainly two advantages. First, it allows for the most compact encoding of typical subtitle streams, including transparent areas, small graphical objects and normal subtitle text. Single pixels of any color, as used for small colorful graphics, are coded with a single byte. The dominant color, e.g. transparent for BDP subtitling, is always encoded together with a run-length. Run-length codes are available in two different sizes, or two pixel quantities. In a first step, run-lengths of up to 63 pixels are available as 2-byte code words for the dominant color, and as 3-byte code words for the other colors. In a second step, run-lengths of up to 16383 pixels are available as 3-byte code words for the dominant color, and as 4-byte code words for the other colors. The end-of-

pixel-string code, or end-of-line code, is a unique 2-byte code word that can be used for resynchronization. Secondly, the availability of longer sequences for the subtitling area, up to 16383 pixels per code word, means a reduction of redundancy, and therefore of the amount of data. This means that for applications with separate data streams sharing one channel, e.g. multiple data streams on an optical storage medium sharing the same pick-up, bigger portions of the subtitling stream may be loaded with the same amount of data, thus reducing the access frequency for the subtitle stream.

Another aspect of the invention is a further optimization of the data stream for transport using transport packets, e.g. in a packetized elementary stream (PES). Due to the large file size of bitmaps, the packaging of such data, e.g. in object data segments (ODS), is a problem. Often the maximum size of an ODS is limited by other factors, e.g. PES packet size. To fit large bitmaps into such packets, it would be necessary to cut bitmaps into small bitmap pieces before coding, which reduces the compression efficiency. To overcome this bitmap splitting, a new extended object data segment (ExODS) for BDP or comparable applications is disclosed, as shown in Fig.4. ExODS is a data structure representing each of the fragments into which an ODS is cut for fitting it into a sequence of limited size segments and PES packets. The complete ODS can be reconstructed by concatenating the sequence of individual pieces of consecutive ExODSs.

The start and the end of a sequence of ExODS is indicated by separate flags, `first_in_sequence` and `last_in_sequence`. When the `first_in_sequence` flag is 1, a new sequence is

starting. An ExODS having set the `first_in_sequence` flag to 1 also indicates the size of the decompressed bitmap, by containing its dimension `object_width` and `object_height`. The advantage of indicating bitmap dimension is the support of target memory allocation before the decompression starts. Another advantage is, that the indicated bitmap dimensions can also be used during decoding for cross checking bitmap dimensions. When the `last_in_sequence` flag is set to 1, the last ExODS of a complete ODS is indicated. There may be ExODS having set neither the `first_in_sequence` nor the `last_in_sequence` flag. These are ExODS pieces in the middle of a sequence. Also the case of having set both, the `first_in_sequence` flag and the `last_in_sequence` flag, is possible if the ODS can be carried within a single ExODS. To overcome the limitation in size available for a single ODS by PES packet size within subtitling, the described type of ExODS may be introduced as a container for pieces of one ODS, e.g. for packaging large ODS for HDTV application. Besides the ODS pieces, the ExODS also carries flags indicating if it is carrying the first piece, the last piece, a middle piece or the one but complete piece of an ExODS sequence. Furthermore, if the first piece in sequence of the ExODS is transmitted, the dimensions of the resulting ODS, i.e. height and width of the encoded bitmap, is contained in the segment. The indicated bitmap dimensions can also be used for a decoding cross check.

The inventive method can be used for compression of bitmap data streams containing e.g. text, images or graphics data for animation, menus, navigation, logos, advertisement, messaging or others, in applications such as e.g. Blu-Ray

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Prerecorded (BDP) discs or generally high-definition video
(HDTV) recordings or broadcast.

Claims

1. A method for run-length encoding of a data stream,
the data stream comprising bitmap formatted subtitle
or menu data for video application, wherein a
preferred color is defined, and the subtitle or menu
data are displayed as a separate layer, overlaying
other displayed data, and wherein
- the shortest type of code words is used for single
pixels having individual color values, the color
not being the preferred color;
 - the second shortest type of code words is used for
shorter sequences of pixels of the preferred
color;
 - the third shortest type of code words is used for
longer sequences of pixels of the preferred color,
wherein the sequence length may exceed the width
of the video display, and shorter sequences of
pixels of other color; and
 - the fourth shortest type of code words is used for
longer sequences of pixels of individual color,
wherein the sequence length may exceed the width
of the video display.
2. Method according to claim 1, wherein the preferred
color is transparent.
3. Method according to any of the previous claims,
wherein redundant code words are used to code
information not referring to pixels of the subtitle
layer.

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4. Method according to any of the previous claims,
wherein the shortest redundant code word is used for
line synchronization.
- 5 5. Method according to any of the previous claims,
wherein the shortest type of code words is one byte
long, the shorter sequences have lengths up to 63
and the longer sequences have lengths up to 16383.
- 10 6. Method according to any of the previous claims,
wherein the encoded data stream is distributed over
multiple transport packets.
- 15 7. An apparatus for run-length encoding of a data
stream, the data stream comprising bitmap formatted
subtitle or menu data for video application, wherein
a preferred color is defined, comprising
- means for encoding single pixels having individual
color other than the preferred color, using the
20 shortest type of code words;
 - means for encoding shorter sequences of pixels of
the preferred color, using the second shortest
type of code words;
 - means for encoding longer sequences of pixels of
25 the preferred color, wherein the sequence length
may exceed the width of the video display, and
shorter sequences of pixels of equal color other
than the preferred color, using the third shortest
type of code words; and
 - 30 - means for encoding longer sequences of pixels of
equal color other than the preferred color,
wherein the sequence length may exceed the width
of the video display, using the fourth shortest

type of code words.

- 5 8. An apparatus for run-length decoding of an encoded data stream containing compressed bitmap formatted subtitle or menu data for video application, wherein a preferred color is defined, comprising
- means for decoding single pixels having individual color other than the preferred color, using the shortest type of code words;
 - 10 - means for decoding shorter sequences of pixels of the preferred color, using the second shortest type of code words;
 - 15 - means for decoding longer sequences of pixels of the preferred color, wherein the sequence length may exceed the width of the video display, and shorter sequences of pixels of equal color other than the preferred color, using the third shortest type of code words; and
 - 20 - means for decoding longer sequences of pixels of equal color other than the preferred color, wherein the sequence length may exceed the width of the video display, using the fourth shortest type of code words.
- 25 9. Apparatus according to claim 7 or 8, wherein the preferred color is transparent.
- 30 10. Apparatus according to any of claims 7-9, further comprising means for encoding or decoding code words that are used to transmit information not referring to pixels of the subtitle layer.

11. Apparatus according to any of claims 7-10,
wherein said encoded data stream is distributed to
multiple transport packets.

Abstract

Subtitling aims at the presentation of text information and graphical data, encoded as pixel bitmaps. The size of subtitle bitmaps may exceed video frame dimensions, so that only portions are displayed at a time. The bitmaps are a separate layer lying above the video, e.g. for synchronized video subtitles, animations and navigation menus, and therefore contain many transparent pixels. An advanced adaptation for bitmap encoding for HDTV, e.g. 1920x1280 pixels per frame as defined for the Blu-ray Disc Prerecorded format, providing optimized compression results for such subtitling bitmaps, is achieved by a four-stage run length encoding. Shorter or longer sequences of pixels of a preferred color, e.g. transparent, are encoded using the second or third shortest code words, while single pixels of different color are encoded using the shortest code words, and sequences of pixels of equal color use the third or fourth shortest code words.

Fig.3

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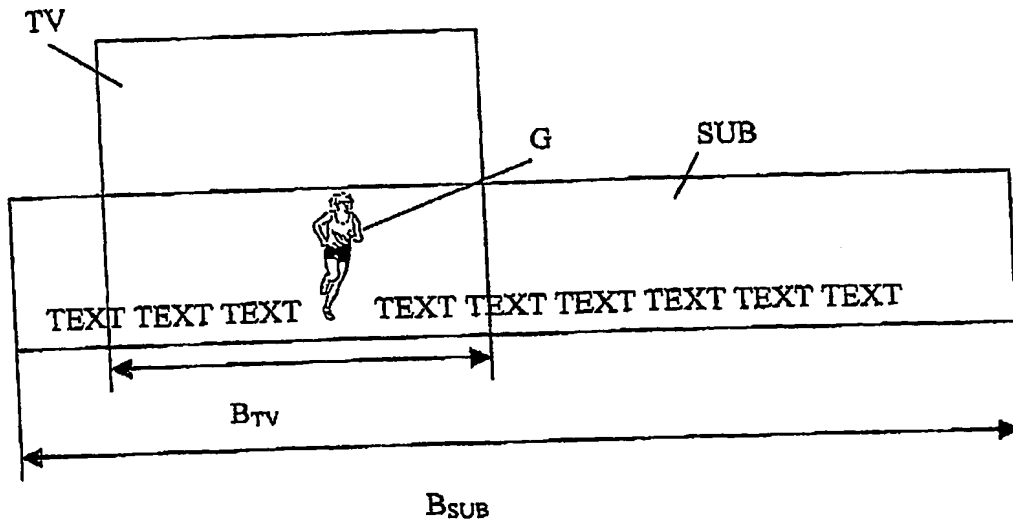


Fig.1

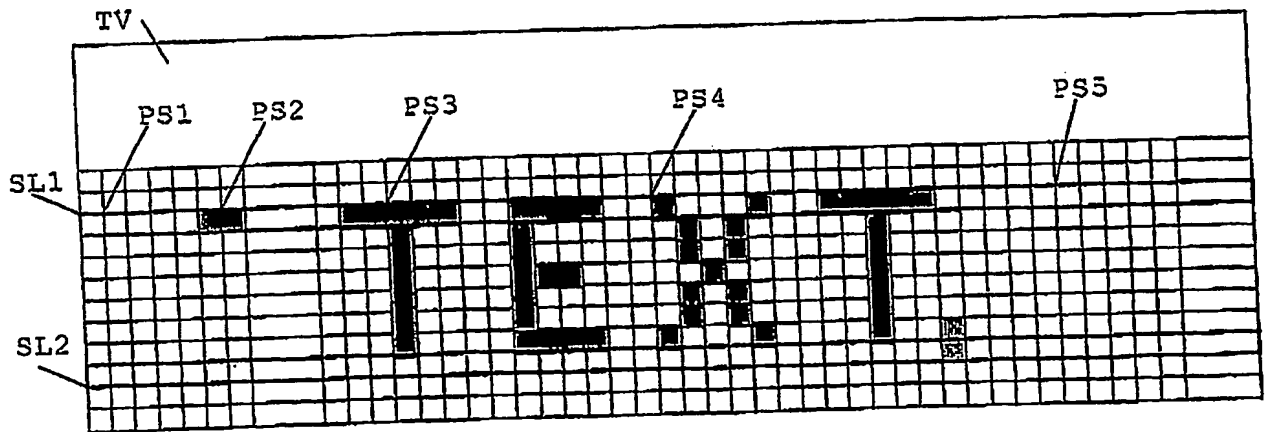


Fig.2

Code	Meaning
CCCCCCCC	One pixel in color C ($1 \leq C \leq 255$)
00000000 00LLLLLL	L pixels in color 0 ($1 \leq L \leq 63$)
00000000 01LLLLLL LLLLLLLL	L pixels in color 0 ($64 \leq L \leq 16383$)
00000000 10LLLLLL CCCCCCCC	L pixels in color C ($3 \leq L \leq 63$, $1 \leq C \leq 255$)
00000000 11LLLLLL LLLLLLLL CCCCCCCC	L pixels in color C ($64 \leq L \leq 16383$, $1 \leq C \leq 255$)
00000000 00000000	end of line
Possible extensions	
00000000 10000000 X	
00000000 10000001 X	
00000000 10000010 X	
00000000 01000000 00000000 X	
00000000 01000000 ...	
00000000 01000000 00011111 X	

Fig. 3

Syntax	Size [bit]	Type
extended object data segment() {		
sync byte		
segment type	8	bslbf
page_id	8	bslbf
segment length	16	bslbf
first in sequence	16	uimbsf
last in sequence	1	bslbf
reserved	1	bslbf
if (first in sequence == '1') {	6	bslbf
object width		
object height	16	uimbsf
}	16	uimbsf
object data piece()		
}		

Fig. 4

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